to its liability of being distributed on nursery stock. It is a native American species and evidently introduced into Europe on rhododendrons exported from America. It is reported from Holland and England and may occur in adjacent countries where rhododendrons are grown. The eggs have been found on rhododendrons received in this country from Holland and England.

EXPLANATION OF PLATE VIII.

Fig. 1. Apical segment of male showing claspers, and dorsal surface.
Fig. 2. Same, ventral surface.
Fig. 3. Ventral surface of female showing ovipositor in position.
Fig. 4. Cross section (at *A-B*, fig. 5) of ovipositor.
Fig. 5. Lateral view of ovipositor.
Fig. 6. Egg in situ.
Fig. 7. Portion of hemielytra showing hairs on dorsal surface.

LIFE HISTORY OF A BOATMAN.

BY H. G. HUNGERFORD,

ITHACA, N. Y.

The rearing of aquatic Hemiptera appears to have been attended with unusual difficulty, and, for this reason, little has been known regarding the life histories of some of them.

However, the fact that our information concerning some of the aquatic bugs has been meager, has not been due to a neglect on the part of our best known workers in this group. For Dr. Kirkaldy, Dr. Abbott, and Mr. de la Torre Bueno have endeavored to provide the much needed information.

The late Dr. Kirkaldy, though a taxonomist primarily, experimented with this phase of the problem. Mr. de la Torre Bueno,[1] who has added more to our knowledge of the life histories of American water bugs than any other, has called attention to the obstacles involved.

Among the most difficult of the aquatic insects to rear have been the water boatmen. Dr. Abbott,[2] our authority in this group, suc-

[1] Can. Ent., X, 1912: p. 113.

[2] *Ramphocorixa balanodis* Abbott, Can. Ent. XXXI, p. 113.

ceeded in rearing *Ramphocorixa acuminata* Uhler. He did so, however, by placing them in a very large aquarium used for breeding mussels. "This was a zinc lined tank about two feet deep, and with a superficial area of thirty or thirty-five square feet, with a layer of soft mud in the bottom of an overflow arrangement by means of which a quiet but constant stream of fresh water was kept circulating through the tank."

His attempts in confinement failed and he was inclined to attribute these failures to the absence of proper food which he supposed to be Ostracods, or similar organisms.

Thus it has happened that until recently the factors necessary for the continuous maintenance of certain forms throughout their developmental lives have remained unknown. However, when the conditions have been discovered, the problem becomes somewhat less difficult.

In a paper on "The Food Habits of Corixids"[3] the writer has pointed out the reason for the failure to rear them in ordinary aquaria. The source of the food supply of the boatmen lies in the brownish sedimentary material at the bottom of the pool, and when this is furnished in fresh supplies each day, they may be reared in remarkably close quarters. The species here described were reared in shallow glass petrie dishes, eleven centimeters in diameter, as many as twelve individuals in each petrie dish. It will thus be noted that they do not destroy one another after the manner of their fierce predatory neighbors.

Our experience with these has shown that they must receive careful attention; the neglect of a day or two will result in disaster, and it has been our custom to visit the pool for fresh corixid food daily.[4]

The adults are said to pass the winter in the mud at the botton of the pools and this year were aroused to activity during the warm days of February.[5] The eggs were laid, in the laboratory, on bits of

[3] Journ. N. Y. Ent. Soc., XXV.

[4] Two broods were reared in ordinary glass aquarium jars, 14 inches in diameter, in which there had been cultures of Nitella, without receiving any attention other than adding water occasionally.

[5] The adults are more or less active in open water any time during the winter. They were taken in numbers at Ithaca, N. Y., January 10, in a spring-fed pool.

cottonwood leaves placed in the aquarium for the purpose. The leaf bits were then transferred to petrie dishes where a careful study of them with the binocular was possible each day. The eggs are laid on the dead leaves and stems of plants lodged in the water. We have found as many as seventy-four eggs on one cottonwood leaf.

There are several generations a year and the eggs of the summer generation are often found on floating weeds and any other available support in the water. The writer has found the eggs of this species, of a small undetermined species, and even those of *Rhamphocorixa acuminata,* which has a peculiar tendency to attach its eggs to the carapace and abdominal pleurites of crayfish, covering tin cans lodged in the water, boards, floating and attached, and even to the shells of living snails. Sticks of log wood of various sizes are sometimes so covered with the eggs of this corixid of the summer generation that it is impossible to handle them without destroying hundreds of eggs.

THE OVUM.

Shape.—The shape of the egg of this species resembles a wooden top, such as the American boy keeps. It sits upon the button end in a disc of leathery material. Eggs of a somewhat similar shape are figured by Metschnikoff, and have been described as pyriform.

Color.—The color, when first laid, is pearly white. This gradually changes to a deep yellow. The red eye spots show very plainly in the more advanced stages. These spots begin to appear about the fourth day as rather indefinite pink patches which gradually darken to a deep red, by which time they then have assumed definite and characteristic shape.

Size.—The greatest length is .581 mm. The greatest diameter is .520 mm.

The egg of this species is figured in Plate IX.

The eggs of two other species are drawn to show the difference in shape, and relative size.

FIRST INSTAR.

Size.—General measurements:

	Mm.
Width of head	.50
Greatest abdominal width	.58
Length of body	1.17

Specific measurements:

	Femur.	Tibia.	Tarsus.	Claw.
Prothoracic leg			.222	
Mesothoracic leg		.249	.291	.332
Metathoracic leg	.291	.291	.533	.249

Color.—When newly hatched, the color is transparent white, the red eyes possessing the only conspicuous coloring matter. The nymph darkens gradually with age, coming finally to a mottled brown, of rather indefinite pattern.

Structural Details.—The nymph appears exceedingly flat. The abdomen is fringed with lateral spines, which on the lateral margin of the last four segments, are quite regularly arranged. There are four spines of unequal length on each. First, a comparatively short spine which is followed by one somewhat longer, and this, in turn, is followed by a long spine, immediately caudad of which, at the latero-caudal point of the segment is a very small spine. On the dorso-lateral surface near the rear margin of each segment is to be found a fine hair. The caudal end of the abdomen bears two short spines, and several pairs of long ones. The eyes are relatively small in comparison with the width of the head. In later instars they become increasingly large as the nymph advances. This point has been noted by Dr. Abbott in the case of *R. acuminata.*

The limbs are more clumsily set up than in the more advanced nymphs; especially is this true of the forelegs. Here the pala is studded with tiny pegs on its inner surface and equipped with the characteristically strong spines and long bristles of the older form. The pegged depression on the inner face of the pala occupies but the outer half of the segments, as shown in the sketch of fifth instar leg, Pl. IX, fig. 10. Compare this with that of the adult, Pl. IX, fig. 12.

The mesothoracic legs are angular limbs, terminating in two long, slightly incurved claws which are larger than the tarsus itself. They are sparsely clothed with bristles. The metathoracic limbs end in long tarsi. They are fringed with about two dozen long hairs in one row, and further equipped with two rows of stiff short spines. The tarsi terminate in a pair of long slender claws, about one third as long as the tarsus itself (see fig. 6). The tibia is slightly thicker than the tarsus and is clothed in a few stout bristles arranged in rows. It is provided near the distal end with a pair of longer bristles,

and a pair of long hairs arranged along the posterior margin of the segment near its base. The femur is somewhat stouter than the tibia and nearly free from spines, though possessing a few slender hairs on its anterior margin. (See fig. 4.)

SECOND INSTAR.

Size.—General measurements:

	Mm.
Width of head	.75
Greatest abdominal width	.90
Length of body	1.63 to 1.78

Specific measurements:

	Femur.	Tibia.	Tarsus.	Claw.
Prothoracic leg			.291	
Mesothoracic leg	.249		.333	.333
Metathoracic leg	.457	.400	.625	

Color.—The general color is arranged in a more distinct pattern than that of the first instar, though not as pronounced as in the next instar. The abdomen is crossed by dark lines, following the point of union of the segments. This banding conspicuously marks the second from the first instar and, in a petrie containing a number, at once distinguished a moulted form from those still in their first stage.

Structural Details.—Much as in previous instar. The lateral spines are now arranged in a different way. Long spines alternating with short ones, five or more to each segment.

The rear margin of the mesothorax is now indicated by a line arcuated as shown in the drawing. (See Pl. IX, fig. 5.)

In specimens about to transform to third instar, the hairs fringing the thorax in the next stage are visible beneath the covering.

THIRD INSTAR.

Size.—General measurements:

	Mm.
Width of head	1
Greatest abdominal width	1.25
Length of body	2.3

Specific measurements:

	Femur.	Tibia.	Tarsus.
Prothoracic leg		.372	.498
Mesothoracic leg	1.16	.526	.498
Metathoracic leg	.66	.623	.919

Color.—The brown color is mottled with markings of gray patches regularly arranged. The black fringe of hairs on the thorax at once marks it from the second instar. Fourth longitudinal bands of light blotches mark the definite pattern on the abdomen.

Structural Peculiarities.—The appearance of the hairs on the thorax as mentioned above and shown in the drawing, Pl. IX, fig. 7, is its most distinctive feature. These fringes enmesh the air and provide a reservoir by means of which the nymph is able to carry below an air supply.[6] It is this instar that the corixid first manifests much concern regarding its air supply. But from this stage on, frequent adjustments of air store are effected. The metathoracic tibia possesses in all the instars a characteristic depression on the rear margin. This is guarded by hairs and appears to be used in this and later nymphal instars to transfer the air held by the hairs on the wing pads and behind the head shield to other portions of the body. It will be noted that the wing pads, which are covered with a pile of short hairs, do not surpass the metathorax. Compare the drawings of this with those of later instars.

The fore femur and tibia are stouter than any of the other limbs, especially the tibia, which is more than half as wide as long.

The mesotarsal claws are still longer than the tarsus itself. The spines on lateral margin of the abdomen are now more numerous than in previous instars, and there are two pairs of short spines on caudal margin of the abdomen.

FOURTH INSTAR.

Size.—General measurements:

	Mm.
Width of head	1.25
Greatest abdominal width	1.62
Length of body	3.5

Specific measurements:

	Femur.	Tibia.	Tarsus.
Prothoracic leg			.684
Mesothoracic leg	1.25	.706	.381
Metathoracic leg	.872	.587	1.41

[6] For a full account of respiration of a Corixid see Johannes Hagemann's paper "Beiträge zur Kenntnis von Corixa" in: Zoologischen Jahrbüchern, Bd. 30, 1910. (Abt. f. Anat.)

Color.—As in the previous instar, but conspicuously darker on thorax, due to the presence of larger wing pads which are fringed with black hairs and covered with a short pile of dark hair.

Structural Details.—The wing pads now extend a little past the thorax and cover at most a third of the first abdominal segment as shown in the drawings.

The hairs on lateral margin of the abdomen are now too numerous and profuse to be characterized.

It may be noted here that the basal half of the fore tibia, as in previous instars, is equipped on its inner margin by a definite patch of minute hairs, reminding one of a part of a tonal device figured by Dr. Abbott.

FIFTH INSTAR.

Size.—*Size.*—General measurements:

	Mm.
Width of head	1.75
Greatest abdominal width	1.75
Length of body	4.375

Specific measurements:

	Femur.	Tibia.	Tarsus.
Prothoracic leg		.618	.787
Mesothoracic leg	1.57	.913	.664
Metathoracic leg	.996	.996	1.66

Color.—Due to its size, the pattern is now distinct, though the same arrangement as in former instars. The abdomen has four broken longitudinal lines, plainly marked, and a faint median line. In all the instars the newly moulted nymph is white to the naked eye. The eyes are red and the margin of the body appears dark, the black hairs giving to the body its only color, save the median dorsal glands which show through as orange red patches. These possess a pair of openings on their caudal convex margins, the anterior margin being broadly heart-shaped.

The newly moulted nymphs make interesting objects for life activity studies. The pulsation of the dorsal vessel, the silvery branching of the tracheæ, the green malphigian tubules and the outline of the digestive tract are inviting to one with an investigational turn of mind.

Structural Details.—As in previous instars, the pegs in the scooping surface are a little longer, but as yet all are alike. There

is no hint of the sexual dimorphism soon to be seen when the adults arrive.

STRUCTURAL CHANGES IN DEVELOPMENT.

In common with all the other water-bugs with which the writer is familiar, the adults differ from the nymphs in the possession of a larger number of tarsal segments.

In this corixid it is interesting to note that the foreleg of the nymph possesses one less than the requisite number of leg segments. In the late fifth instar the terminal segment of the nymph may be seen to contain the tibial and tarsal segments of the adult (see fig. 10). The middle leg has the same number of segments in the nymph as in the adult. The tarsus of the hind leg is one-segmented and the two segments of the adult can be seen within, shortly before transformation.

All the nymphs have two distinct claws on the hind tarsi. These are very distinct in the first instar as shown in fig. 6.

The antennæ of the nymphs are two-segmented but four-segmented in the adult. The terminal segment of the late fifth instar nymph incases the three outer segments of the adult (Pl. IX, fig. 15).

THE ADULTS.

A technical description of this species is not attempted. Its limits have not been defined, as yet, by Dr. Abbott, who is working on a monograph of this difficult group. It is to be hoped that the above mentioned monograph will be made available to the general worker at an early date. At present we must content ourselves with indefinite designations.[7]

The species whose life history is here presented is a common one in our ponds and pools in Kansas. It is especially in evidence in the clear small pools which in excessively dry seasons disappear.

This corixid is of medium size and barred with a pattern of yellow and brown. The arrangement of the darker pigment pattern being delineated in fig. 2.[8]

Like other corixids, the males and females are to be distinguished by the somewhat larger size of the female and by the peculiar asymmetry of the abdominal segments of the male, as shown in the sketch

[7] Dr. Abbott has stated that this species is a member of the alternata series.

[8] Drawn for me by Miss Edmonson, a Junior in the department of Entomology of University of Kansas.

(fig. 17). There is also a certain sexual dimorphism manifest in the pala, or terminal segment of the foreleg.

LABORATORY STUDIES.

After having discovered the source of their food supply, the glass petries employed in bacteriological work were found admirably suited to the needs of one wishing to study the habits and life history of these boatmen.

In order to obtain definite data on the number and length of the instars, newly hatched corixids were isolated in 11 cm. petrie dishes, and the dates of ecdysis recorded.

In addition, they were reared in petries and also in large porcelain-ware pie-pans, as general checks on the isolated rearings. All of the laboratory observations were accompanied by observations of the general cycle in nature.

Space does not permit the recording of the notes on all the lot rearings, but two are herewith presented to suggest in a general way the variation of development for the spring generation.

Petrie F.—A petrie dish, 15 cm. in diameter, was chosen to carry an entire lot through as a general control on the isolated rearings.

Eggs were laid on a large dead cottonwood leaf in the laboratory between the afternoon of March 25 and the morning of March 27.

On April 8, two were hatched, and the remaining eggs showed the red eye spots of the embryo within. The eggs continued to hatch until April 14. On this day, one entered the second instar. April 20, the first entered the third instar, and by April 24 there were several in this stage. On Friday, April 28, one passed into the fourth instar, and in the next few days, the others followed it. The first entered the fifth instar on May 4, and all had reached this stage by May 6. The first adult, a male, appeared May 10. The last adult came forth May 17. So, for this lot, we see that eggs laid about March 26 gave forth adults from May 10 to May 17, a period covering from about 45 to 53 days, and allowing a variation of about a week in the development of boatmen from a single laying. This is evidence enough that the rearing should be carried out on a much larger scale than is presented in this paper, in order to ascertain the maximum time to be found in each period of development.

Petrie K.—Since this series represents the second lot and was started some two weeks later than those of lot one, a large petrie similar to petrie *F,* was used as general check on the isolation rearings. The eggs were laid on a leaf, during the night of April 11. By April 16 the red eye spots had appeared on several, and at least a dozen had hatched by April 19. The remainder of the eggs showed red eye spots. All had hatched by April 20, and the petrie was swarming with young corixids. Many were removed to make room for the number permitted to remain—still a goodly number. April 25 marked the first one to come forth into the second instar. It was milky white with red eyes, and the large glands beneath the dorsal wall of the abdomen showed plainly. The tracheæ were to be seen as silver threads branching through the body. April 27 records many second instar forms and on May 2, third instar forms began to appear, so that all were in this stage by May 4. On May 7 approximately half of the nymphs were fourth instars, and now measuring in length about the diameter of the field of the binocular being used. (Zeiss, 2x eyepiece, 3 A objective.)

The first fifth instar form came May 13, followed by two more the next day, and all of the rest by May 16. Two adults appeared on May 24, and others followed during the next two days. They were confined here to obtain the time required for coming to maturity, but they died, one by one, till the last one departed June 25, after having lived in the petrie as an adult at least a month. It proved to be a male. For this lot, from eggs laid April 11, adults appeared during the period from May 24 to May 26, allowing 43 to 45 days for their development, a time somewhat shorter than those recorded in petrie *F.*

CONCLUSION.

The notes above presented record the first rearing of the boatmen in close quarters. Rearing may be carried on in petril dishes if given daily attention. In large aquaria, prepared before hand and allowed to reach a natural condition of balance the five or six species with which the writer has had experience may be followed through their life cycles with slight attention.

In nature the majority of the Boatmen spend their time on the bottom of the shallower parts of the ponds and pools. Foraging midst

the flocculent deposits at the bottom of the pool they gather the organic ooze and some of the population both plant and animal that it contains. The living organisms consumed in their feeding range from the filamentous algæ to rotifers and oligochæte worms.

They in turn are preyed upon by many aquatic carnivores and may be looked upon as members of the producing class.

Their eggs appear a little earlier in the spring than those of *Notonecta*. The incubation period of the egg covers a week, and each of the five nymphal instars requires approximately a like time,[9] thus bringing them to the adult stage in some six weeks. While they may be found many times in all stages of development, the definite broods are not difficult to follow in nature, and in proper waters, with an absence of a dominating predatory population, they thrive in astonishing numbers.

Of all the true water bugs, they alone have been found the forage of any of the fishes. May they in some small measure at least ameliorate the unfortunate reputation of the rest of the water bugs, whose predatory and cannabilistic tendencies have been many times recorded.

EXPLANATION OF PLATE IX.

Fig. 1. Egg of the corixid species here considered.

Fig. 2. Adult corixid, *Artocorixa alternata?*

Fig. 3. Egg of a smaller undetermined species.

Fig. 4. First instar nymph.

Fig. 5. Second instar nymph.

Fig. 6. Tarsus and claws of hind leg of first instar.

Fig. 7. Third instar. Note the fringe of black hairs on the wing pads.

Fig. 8. Egg shell after hatching, showing the characteristic rupturing of the egg for the egress of the nymph.

Fig. 9. Fourth instar nymph.

Fig. 10. Front leg of late fifth instar nymph showing the tibia and tarsus of the adult within the terminal nymphal segment.

Fig. 11. Fifth instar nymph.

Fig. 12. The foreleg of the adult male.

Fig. 13. Ventral view of abdomen of female.

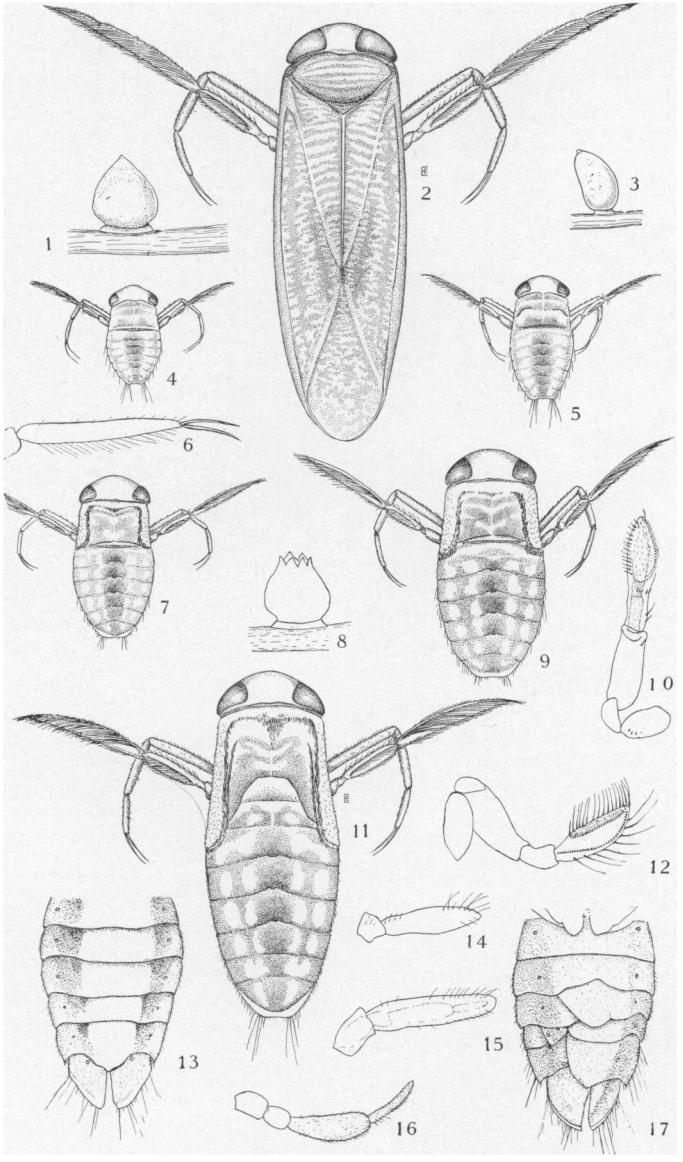
Fig. 14. Antenna of third instar nymph.

Fig. 15. Antenna of late fifth instar, showing the three distal segments of the adult in the terminal nymphal segment.

Fig. 16. Antenna of adult.

Fig. 17. Ventral view of abdomen of male, showing the peculiar asymmetry of the segments.

[9] The last nymphal instar often requires a longer time.



Corixa